Calhoun: The NPS Institutional Archive

DSpace Repository

Theses and Dissertations 1. Thesis and Dissertation Collection, all items

1983-12

A variable input-output model for inflation, growth, and energy for the Korean economy

Chang, Sang Chul; Hwang, Yong Roo

http://hdl.handle.net/10945/20030

Downloaded from NPS Archive: Calhoun

Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

http://www.nps.edu/library

CALIFORNIA 93943

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A VARIABLE INPUT-OUTPUT MODEL FOR INFLATION, GROWTH, AND ENERGY FOR THE KOREAN ECONOMY

by

Sang Chul Chang
and
Yong Roo Hwang

December 1983

Co-advisors: C.R. Jones
J.W. Creighton

Approved for public release; distribution unlimited

T21

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Variable Input-Output Model for Inflation, Growth, and Energy for the Korean Economy		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis December 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Sang Chul Chang Yong Roo Hwang		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943		12. REPORT DATE December 1983
		13. NUMBER OF PAGES 56
14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Model, Inflation, Function, Frontier, Multiplier,
Hike, Growth, Capital, Price, Coefficient,
Money, Input, Output, Variable, Simulation.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Regional multipliers are a useful and popular tool in the economic study of a region. However, conventional regional multipliers derived from a static input-output model fail to provide the time path of the impact over period. In many cases, the time restricts the impact within a year period. To alleviate the problem, this thesis introduces a regional dynamic multiplier model which spreads the impact out over

time. In the absence of technical change, each periods multiplier adds up to the static multiplier. Utilizing the Korean economy data, the thesis estimates the capital coefficients and the dynamic multipliers for the Korean ecomony. Finally, it provides a comparative simulation study in addition to the dynamic multipliers for various industry.

Approved for public release; distribution unlimited.

A Variable Input-Output Model for Inflation, Growth, and Energy for the Korean Economy

by

Sang Chul Chang
Major, Republic of Korea Army
B.S., Korean Military Academy, 1976

and

Yong Roo Hwang
Major, Republic of Korea Army
B.S., Korean Military Academy, 1973

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1983

Thesis
L3716
c.1

ABSTRACT

Regional multipliers are a useful and popular tool in the economic study of a region. However, conventional regional multipliers derived from a static input-output model fail to provide the time path of the impact over period. In many cases, the time restricts the impact within a year period. To alleviate the problem, this thesis introduces a regional dynamic multiplier model which spreads the impact out over time. In the absence of technical change, each periods multiplier adds up to the static multiplier. Utilizing the Korean economy data, the thesis estimates the capital coefficients and the dynamic multipliers for the Korean ecomony. Finally, it provides a comparative simulation study in addition to the dynamic multipliers for various industries.

TABLE OF CONTENTS

I. INTRODUCTION 7

II. THE VARIABLE INPUT-OUTPUT MODEL 13

A. THE COBB-DOUGLAS PRODUCTION AND PRICE FRONTIERS 14

B. CES PRODUCTION AND PRICE FRONTIERS 19

III. MULTIPLIER ANALYSIS AND OUTPUT DETERMINATION 24

IV EMPIRICAL FINDINGS 32

A. INPUT ELASTICITIES 33

B. MULTIPLIER ANALYSIS 37

C. SIMULATION ANALYSIS 42

V. CONCLUSIONS 52

LIST OF REFERENCES 54

INITIAL DISTRIBUTION LIST 56

LIST OF TABLES

I. The Structure of the Variable Input-Output Model 24

II. Industrial Classification 33

III. Input Elasticities, Labor Coefficients, Capital Coefficients, and Tax Rates 35

IV. Multiplier Analysis 38

V. Simulation Results on Inflation 44

VI. Simulation Results on Industrial Input Purchases 48

I. INTRODUCTION

More than twenty percent rate of inflation has brought a concern to both politicians and economists. Inflation has become a major economic and political issue in recent years. Some economists used to think that a developing economy needs some sort of inflation. When an economy is expanding, business firms need money to expand thier facilities, and inflation makes it easier for them to operate the business. The Phillips Curve suggests that inflation and recession should have an inverse relation. It is also considered that a rapidly developing economy will inevitably have some sort of inflation. Contrary to these views, the recent inflation comes with recession. Keynesian economics fails to provide a satisfactory solution to the stagflation. Government spending as a stimulus to economic development simply does not work for the stagflation.

Stagflation stems from cost push. The Korean government blames OPEC price hikes on crude petroleum and world wide inflation, particularly the inflation in the U.S., for the Korean inflation. The import prices of all capital goods and energies have become too expensive and it is inevitable that the government raised controlled prices. Industries

need more money to buy these expensive products and an increase in money supply is a necessary step to avoid any further burdens to the business firms which already face a shortage of money. The government provides low interest loans and encourages non-union types of wage negotiation to minimize the cost increase to the firms.

Inflation, growth, and energy supplies are the most important problems which the Korean economy must face today. To answer these questions, economists and government organizations have built many interesting short-run and long-run aggregate economic models. There are two popular approaches: 1) aggregate econometric models and 2) input-output models.

The Korean Development Institute(KDI) [Ref. 1] and Bank of Korea(BOK) [Ref. 2] aggregate econometric models are examples of the first group. Those econometric models are very valuable stepping-stones toward the construction of practical and useful economic models.

They are built on the assumption that each endogenous variable is related to other variables with a coefficient which is invariant over time period. In many cases, the stability of the estimated coefficients over a period is challenged. By adding a set of new data to the model and running the same structural equations, shows that structural coefficients keep changing.

The possible source of errors is the presence of irrelevant variables or bias from the omitted variables, or the wrong choice of either functional forms or explanatory variables. It is evident that multiplier analysis or simulation results from such aggregate econometric models may not be reliable. A continuing search for the reliable econometric models for the Korean economy is currently being undertaken by various groups of econometric researchers.

Another popular tool for forecasting future economic conditions and tracing the economic impact of outside shocks is the input-output analysis. It is fortunate to have a series of input-output transaction tables [Ref. 3] for the Korean economy.

The usual input-output analysis is done under the assumption that the technical coefficients are invariant over a time period. One difficulty with the fixed coefficient model is it is incapabile of incorporating the economizing behavior of firms into the models. The 1979 oil crisis is an illustration. An increase in crude oil prices should affect the technical coefficients. The fixed coefficient model fails to respond to the firm's efforts to substitute less expensive energy sources for the expensive crude oil.

To make the input-output model more flexible so as to respond to such economizing behavior of firms, a variable

input-output coefficient model is introduced for the Korean economy. An interesting feature of the input-output model is its variable coefficients which are derived from the basic duality between production and price possibility frontiers. From the dual relations, a set of price frontiers can be obtained. These prices depend on input elasticities, service prices of capital stocks, wage rates, the service price of money and technical progress. These variables affect the technical coefficients through the price variables.

The purchase price of inputs, technical change, and the sales price of output as determinants of the technical coefficients were suggested by Walras [Ref. 4] and many other economists. [Ref. 5]

Arrow-Hoffenberg [Ref. 6] attempted to forecast target year input-output coefficients from the base year coefficients, real output, and a ratio of defense spending to real output. Another approach to variable input-output coefficients is the RAS method. The RAS method [Ref. 7] computes the target year coefficients from the base year coefficients. However, these two approaches are not capable of tracing the exogenous shocks such as the oil crisis because of the models' incapability to respond to the input price change. Recently, Hudson and Jorgenson [Ref. 5] introduced an interesting macro-inter-industry model. They

successfully introduced prices into the variation of technical coefficients. Their model attempts to solve both macro and interindustry variables by using the translog price frontiers as a starting point. A further disaggregation of the industrial sectors was done by a sequential method.

The model is derived from the basic duality. Instead of starting from a translog price frontier, it is assumed that each output is produced by additive and homogenous production frontiers. An additive and homogenous price frontier for each product is derived from the profit maximizing conditions. By jointly solving the price frontiers, profit maximizing price levels are obtained. The variable input-output coefficients are derived from the input-output transformation relations. It is assumed that macro variables are exogenously intertwined

Another interesting feature of the model is its capability to identify the sources of cost push inflation and its chain impact. Wage-related price multipliers, money-related price multipliers, capital related price multipliers, and non-tax related price multipliers are introduced. These multipliers identify the contribution of an increase in these primary input prices and a tax cut to the rates of inflation in the Korean economy.

The model is also used as a simulation to observe the stagflation of the Korean economy when energy prices go up or when the government controlled essential prices are raised. It shows both the rate of recession and the rate of inflation when these outside shocks are introduced into the economy.

II. THE VARIABLE INPUT-OUTPUT MODEL

Consider the following production function: [Ref. 8]

$$f(x_1, x_2, \ldots\ldots\ldots x_n, y) \quad \ldots\ldots\ldots (2-1)$$

where x_i is the ith input to produce the output y, and p_i and p are the ith input price and the output price respectively.

The usual profit maximizing relations are:

$$\frac{f_y}{f_i} = \frac{p}{p_i} \quad \text{and} \quad \frac{f_i}{f_j} = \frac{p_i}{p_j} \quad \ldots\ldots (2-2)$$

$$(i = j, \; i,j = 1, 2, \ldots, n)$$

where f_y and f_i are the partial derivatives of the production frontier with respect to the output and the ith input respectively. The price frontier is obtained from (2-1) and (2-2). It is represented as:

$$g(p_1, p_2, \ldots p_n, p) = 0 \quad \ldots\ldots\ldots\ldots (2-3)$$

The variable input-output coefficients are derived from (2-2). The discussion of the dual relation between the production frontier and the price frontiers in the Cobb-Douglas and the Constant Elasticitiy of Substitution (CES) cases will be presented.

A. THE COBB-DOUGLAS PRODUCTION AND PRICE FRONTIERS

Each industrial output is produced by a Cobb-Douglas production frontier.

$$\ln x_j - A_{oj} - \sum_{i=1}^{n} A_{ij} \ln x_{ij} - B_j \ln M_j - C_j \ln L_j - D_j \ln K_j = 0 \quad \ldots\ldots(2\text{-}4)$$

$$(j = 1, 2, \ldots, n)$$

where x_j = output of the jth industrial sector;

x_{ij} = intermediate purchase of the ith output by the jth industry;

M_j = quantity of money employed by the jth industry;

L_j = labor services employed by the jth industry;

K_j = quantity of capital employed by the jth industry

A_{ij}, B_j, C_j and D_j are the input elasticities of intermediate inputs, money service, labor service and capital service respectively. A_{oj} is the technical progress parameters.

The Cobb-Douglas production frontiers are assumed to be linear homogenous; i.e.,

$$\sum_{i=1}^{n} A_{ij} + B_j + C_j + D_j = 1 \ldots\ldots\ldots(2\text{-}5)$$

The profit maximizing relationships are:

$$-\frac{f_j}{f_{ij}} = \frac{(1-t_j)p_j}{p_i} \qquad \text{.........(2-6)}$$

$$-\frac{f_j}{f_{Mj}} = \frac{(1-t_j)p_j}{v_j} \qquad \text{.........(2-7)}$$

$$-\frac{f_j}{f_{Lj}} = \frac{(1-t_j)p_j}{w_j} \qquad \text{.........(2-8)}$$

$$-\frac{f_j}{f_{Kj}} = \frac{(1-t_j)p_j}{r_{ij}} \qquad \text{.........(2-9)}$$

Here f_j, f_{ij}, f_{Mj}, f_{Lj}, and f_{Kj} are the partial derivatives of the Cobb-Douglas production frontiers with respect to x_j, x_{ij}, M_j, L_j, and K_j respectively. p_i, v_j, w_j, and r_j are respectively the input price of x_{ij}, the price of money, the wage rate and the price of capital. t_j and p_j are the effective tax rate and the output price by the jth industry. M_j, L_j and K_j are quantity indices of money, labor and the capital (stock) by the jth industry respectively.

From equations (2-6) to (2-9), the following profit maximizing input demand functions are obtained:

$$x_{ij} = A_{ij}(1-t_j)p_j x_j / p_i \quad \ldots\ldots\ldots(2\text{-}10)$$

$$M_j = B_j(1-t_j)p_j x_j / v_j \quad \ldots\ldots\ldots(2\text{-}11)$$

$$L_j = C_j(1-t_j)p_j x_j / w_j \quad \ldots\ldots\ldots(2\text{-}12)$$

$$K_j = D_j(1-t_j)p_j x_j / r_j \quad \ldots\ldots\ldots(2\text{-}13)$$

The Cobb-Douglas production functions (2-4) and the input demand equations (2-10) to (2-13) are combined to yield:

$$\begin{aligned}
&\ln x_j - A_{cj} - \sum_{i=1}^{n} A_{ij} \ln(A_{ij}(1-t_j)p_j x_j / p_j) \\
&- B_j \ln(B_j(1-t_j)p_j x_j / v_j) - C_j \ln(C_j(1-t_j)p_j x_j / w_j) \\
&- D_j \ln(D_j(1-t_j)p_j x_j / r_j) \\
&= \ln x_j - (A_{cj} + \sum_{i=1}^{n} A_{ij} \ln A_{ij} + B_j \ln B_j + C_j \ln C_j + D_j \ln D_j) \\
&- (\sum_{i=1}^{n} A_{ij} + B_j + C_j + D_j)(\ln(i-t_j) + \ln p_j + \ln x_j) \\
&+ \sum_{i=1}^{n} A_{ij} \ln p_j + B_j \ln v_j + C_j \ln w_j + D_j \ln r_j \quad \ldots.(2\text{-}14)
\end{aligned}$$

By the assumption of the linear homogeneity (2-5), the $\ln x_j$

algebrically vanishes equations (2-14) and the following Cobb-Douglas price frontiers are obtained:

$$\ln p_j - \sum_{i=1}^{n} A_{ij} \ln p_j = c_j - \ln(1-t_j) + B_j \ln v_j + C_j \ln w_j + D_j \ln r_j + \dots \qquad \dots\dots\dots (2\text{-}15)$$

where $c_j = -(A_{cj} + \sum_{i=1}^{n} A_{ij} \ln A_{ij} + B_j \ln B_j + C_j \ln C_j + D_j \ln D_j)$

The Cobb-Douglas price frontiers (2-15) can be conveniently represented as the following vector function:

$$(I-S)\ln p = \hat{c} - \hat{\ln}(i-t) + \hat{B}\ln v + \hat{C}\ln w + \hat{D}\ln r \dots \qquad (2\text{-}16)$$

where

$$S = \begin{pmatrix} A_{11} & \dots & A_{n1} \\ \vdots & & \vdots \\ A_{1n} & \dots & A_{nn} \end{pmatrix} \qquad \ln p = \begin{pmatrix} \ln p_1 \\ \vdots \\ \ln p_n \end{pmatrix}$$

$$\ln v = \begin{pmatrix} \ln v_1 \\ \vdots \\ \ln v_n \end{pmatrix} \qquad \ln w = \begin{pmatrix} \ln w_1 \\ \vdots \\ \ln w_n \end{pmatrix} \qquad \ln r = \begin{pmatrix} \ln r_1 \\ \vdots \\ \ln r_n \end{pmatrix}$$

where $\hat{c}$, $\hat{\ln}(1-t)$, $\hat{B}$, $\hat{C}$ and $\hat{D}$ are n by n diagonal matrices of c_i, $\ln(1-t_i)$, B_i, C_i and D_i respectively for i=1, 2, ...,n. I is an n by n identity matrix.

The Cobb-Douglas price frontiers contain the effective tax rate (t_j), the price of money(v_j), the wage rate(w_j), the price of capital(r_j), the input elasticities(A_{ij}, B_j, C_j, D_j) and the technical progress parameters(A_{oj}) as exogenous input.

In general, the profit maximizing price level has a positive relation with tax rates, the price of money, the wage rate, the price of capital, and a negative relation with the input elasticities and the technical progress parameters. By jointly solving the price frontier equations (2-15), the n profit maximizing price levels is obtained,i.e.,

$$p_i = p_i(t_j, v_j, w_j, r_j, B_j, C_j, D_j, A_{oj}, A_{ij}) \quad ..(2-17)$$

From the input demand equations (2-10) which were obtained from the profit maximizing relations (2-16), the input-output coefficient functions is derived:

$$a_{ij} = \frac{x_{ij}}{x_j} = A_{ij}(1-t_j)\frac{p_j}{p_i} \quad ....(2-18)$$

From (2-17) and (2-18), the variable input-output coefficients which are expressed in terms of the effective tax rates, the price of money, the wage rate, the price of capital, input elasticities and the technical progress parameters will be obtained;

namely:

$$A_{ij} = A_{ij}(t_j, v_j, w_j, r_j, A_j, B_j, C_j, D_j, A_{oj}, A_{ij}) \qquad \text{............(2-19)}$$

B. CES PRODUCTION AND PRICE FRONTIERS

There is an assumption that each industrial output is produced by CES production frontiers. The Cobb-Douglas frontiers are a special case of the CES frontiers.

$$X_j^{-m_j} - \sum_{i=1}^{n} b_{ij} X_{ij}^{-m_j} - c_j M_j^{-m_j} - d_j L_j^{-m_j} - e_j K_j^{-m_j} = 0 \qquad \text{.............(2-20)}$$

where m_j is a substitution parameter of the jth industry $(m_j \geq -1)$. b_{ij}, c_j, d_j and e_j are distribution parameters for the intermediate inputs, money, labor service, and the capital service, respectively.

The profit maximizing relations are:

$$-\frac{F_j}{F_{ij}} = (1-t_j)\frac{p_j}{p_i} \quad \ldots\ldots\ldots(2\text{-}21)$$

$$-\frac{F_j}{F_{Mj}} = (1-t_j)\frac{p_j}{v_j} \quad \ldots\ldots\ldots(2\text{-}22)$$

$$-\frac{F_j}{F_{Lj}} = (1-t_j)\frac{p_j}{w_j} \quad \ldots\ldots\ldots(2\text{-}23)$$

$$-\frac{F_j}{F_{Kj}} = (1-t_j)\frac{p_j}{r_j} \quad \ldots\ldots\ldots(2\text{-}24)$$

where F_j, F_{ij}, F_{Mj}, F_{Lj} and F_{Kj} are the partial derivatives of the CES production frontiers with respect to x_j, x_{ij}, M_j, L_j, and K_j respectively.

From equations (2-21) to (2-24), the following profit maximizing input demand functions are obtained:

$$x_{ij} = \left(b_{ij}(1-t_j)\frac{p_j}{p_i}\right)^{q_j} x_j \quad \ldots\ldots(2\text{-}25)$$

$$M_j = \left(c_j(1-t_j)\frac{p_j}{v_j}\right)^{q_j} x_j \quad \ldots\ldots(2\text{-}26)$$

$$L_j = (d_j (1-t_j) \frac{p_j}{w_j})^{q_j} x_j \quad \text{......(2-27)}$$

$$K_j = (e_j (1-t_j) \frac{p_j}{r_j})^{q_j} x_j \quad \text{......(2-28)}$$

Where q_j is the elasticity of the substitution between two inputs by industry j (i.e., $q_j = 1/1+q_j$).

By jointly solving using the CES production functions (2-20) and the input demand functions (2-25) to (2-28), the following equations are obtained:

$$\begin{aligned} x_j^{-q_j} &- \sum_{i=1}^{n} b_{ij} (b_{ij} (1-t_j) \frac{p_j}{p_i})^{q_j} x_j)^{-q_j} \\ &- c_j ((c_j (1-t_j) \frac{p_j}{v_j})^{q_j} x_j)^{-q_j} \\ &- d_j ((d_j (1-t_j) \frac{p_j}{w_j})^{q_j} x_j)^{-q_j} \\ &- e_j ((e_j (1-t_j) \frac{p_j}{r_j})^{q_j} x_j)^{-q_j} = 0 \quad \text{......(2-29)} \end{aligned}$$

Where the distribution parameters(b_{ij}, c_j, d_j, e_j) add up to unity, i.e.,

$$\sum_{i=1}^{n} b_{ij} + c_j + d_j + e_j = 1 \quad \text{......(2-29)}$$

Equation (2-29) reduces to the following CES price frontiers. The output variable(x_j) vanishes in the equations. The CES price frontiers can be conveniently represented in the matrix form:

$$(I - b^*)p^* = Z^* \quad \text{......(2-31)}$$

where

$$p^* = \begin{pmatrix} p_1^{mq_j} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ p_n^{mq_j} \end{pmatrix} \quad b^* = \begin{pmatrix} b_{11}^* & \cdots & b_{n1}^* \\ \vdots & \ddots & \vdots \\ b_{1n}^* & \cdots & b_{nn}^* \end{pmatrix} \quad Z^* = \begin{pmatrix} Z_1^* \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ Z_n^* \end{pmatrix}$$

$$b_{ij}^* = b_{ij}\,(b_{ij}\,(1-t_j))^{-mq_j}$$

$$Z_j^* = c_j\,(c_j\,(1-t_j))^{-mq_j} . v_j^{mq_j} + d_j\,(d_j\,(1-t_j))^{-mq_j} . w_j^{mq_j}$$

$$+ e_j\,(e_j\,(1-t_j))^{-mq_j} . r_j^{mq_j} . \quad \text{(for } j = 1, 2, \ldots n)$$

I is an n by n identity matrix.

mq_j is $m_j q_j$.

From the profit maximizing input demand equations, the variable input-output coefficients are derived.

$$a_{ij} = \frac{x_{ij}}{x_j} = \left(b_{ij}(1-t_j)\frac{p_j}{p_i}\right)^{q_j} \quad \text{......(2-32)}$$

By jointly solving the CES price frontiers (2-31), the equilibrium industrial prices were obtained. These prices depend on the effective tax rate(t_j), the price of money (v_j), the wage rate(w_j), the price of capital(r_j), the substitution parameters(m_j), the elasticity of substitution (q_j) and the distribution parameters(b_{ij}, c_j, d_j, e_j).

These exogenous variables and parameters affect the technical coefficients through the equilibrium price levels.

The CES variable input-output coefficients deppend on those exogenous variables and parameters:

$$a_{ij} = a_{ij}(t_j, v_j, w_j, r_j, m_j, q_j, b_{ij}, c_j, d_j, e_j) \text{...(2-33)}$$

When the elasticity of substitution between two inputs becomes unity, the CES variable input-output model becomes the Cobb-Douglas model.

III. MULTIPLIER ANALYSIS AND OUTPUT DETERMINATION

Table I provides the basic structure of the variable input-output model.

TABLE I

The Structure of the Variable Input-Output Model

Exogenous Variable	Parameters	Endogenous Variable
1. Primary input price	1. Inputt elasticities	1. Technical coefficients
a. wage rate		
b. Price of capital	2. Technical progress parameters	2. Interindustry transaction
c. Price of money		
2. Final Demand components		3. Output, income, and employment
a. Consumption		
b. Investment		4. Industrial Prices
c. Government spendings		
d. Net export		5. Price multiplier
e. Inventory changes		6. Output, income, and employment multipliers
3. Tax Structure		

The model assumes that the input elasticities and the technical progress parameters are independent of a change in either primary input prices or final demand components. Exogenous variables to the model are the wage rate, the price of capital, the price of money, the tax rates, and the final demand components. Endogenous variables of the model are technical coefficients, industrial outputs, income, employment, industrial prices, interindustry transactions, and various multipliers.

Any change in an exogenous variable affects the technical coefficients and other endogenous variables. It is evaluated step by step using the procedure by which the exogenous variable changes those exogenous variables.

By taking a derivative of the price frontier equations (2-16) with respect to the primary input prices and tax rate, the following price multipliers are obtained:

$$\frac{\partial \ln p}{\partial \ln v} = ((I - S)^{-1} B)' \quad ......(3\text{-}1)$$

$$\frac{\partial \ln p}{\partial \ln w} = ((I - S)^{-1} C)' \quad ......(3\text{-}2)$$

$$\frac{\partial \ln p}{\partial \ln r} = ((I - S)^{-1} D)' \quad ......(3\text{-}3)$$

$$\frac{\partial \ln p}{\partial \ln (1-t)} = (-(I - S)^{-1})' \quad ......(3\text{-}4)$$

Equation (3-1) shows the relation between and rate of change in the price of money and the corresponding change in inflation rate. As the price of money becomes expensive, it further increases the inflation rate. The service price of money includes the cost of holding money. As people expect more inflation (in the future), the price of money becomes more expensive and it further increases the inflation rates. Real estate speculation such as buying lands, housing, and apartments is a clear sign that the price of money becomes expensive. The low cost export financing is a government effort to lower the price of money.

Equation (3-2) indicates the inflationary impact of the wage rate. Establishment of a minimum wage is often opposed because it is inflationary. The inflationary impact of wage increases is different depending on the wages of which industry is hiked. The wage-related price multiplier answers the question.

The price of capital includes the cost of capital and the price of lands. The interest payment and depreciation of the capital stock are part of the price of capital. An increased lending rate on the purchase of a machine raises the price of capital which in turn raises the prices of all commodities. The price of capital-related multipliers answers how much the price of each commodity goes up when there is a one percent increase in the price of capital for

the industry. The right-hand expression of the equation (3-3) denotes the service capital-related price multiplier.

Tax is a part of business expense. Higher tax rates increase the firms cost, and the firm may pass the cost on to the user of the products. In our model, the non-tax portion(i-t) instead of the tax portion(t) will be used. As the non-tax portion increases, firms lower the price level. Since all other industries now purchase cheaper products, they lower the price of their porduct. This chain impact is measured by the non-tax-portion-related price multipliers. The right-hand expression of equation (3-4) shows the non-tax portion related price multipliers.

Next, the way by which primary input price affects the variable input-output coefficients is evaluated. From equation (2-18), the following relationship is evident:

$$\ln a_{ij} = \ln A_{ij} + \ln(1-t_j) + \ln p_j - \ln p_i \quad \ldots\ldots(3\text{-}5)$$

Suppose that the wage is the only change in the economy, the rate of change in variable input-output coefficients due to the wage change can be identified as below:

$$\frac{\partial \ln a_{ij}}{\partial \ln w_K} = \frac{\partial \ln p_j}{\partial \ln w_k} - \frac{\partial \ln p_i}{\partial \ln w_k} \quad \ldots\ldots(3\text{-}6)$$

$$(i,\ j,\ k = 1,\ 2,\ \ldots\ n)$$

The right-hand expression of equation (3-6) are identifiatle from the equation (3-2). Suppose, there are

base year input-output coefficients($a_{ij}, (t_0)$); and the new coefficients($a_{ij}, (t_1)$) are evaluated after the wage change as below:

$$a_{ij}(t_1) = a_{ij}(t_0).\mathrm{Exp}(\partial \ln p_j - \partial \ln p_i) \quad ......(3-7)$$

(Note : $\ln a_{ij}$ can be approximated by ($\ln a_{ij}(t_1) - \ln a_{ij}(t)$ or $\ln(a_{ij}(t_1)/a_{ij}(t))$.
The $\partial \ln p_j$ and $\partial \ln p_i$ are the change in equilibrium prices due to the wage change.

Similarly, the rate of change in variable input-output coefficients resulting from a change in other primary input prices such as the price of money and the price of capital can be traced.

A change in input-output coefficients results in a change in industrial outputs, income, and employment. Any change in primary input prices not only affects the inflation but also the growth of the Korean economy. The variable input-output model identifies both industrial growth and inflation for the Korean economy, a feature not shared by the conventional input-output model.

The industrial outputs are determined by the usual balance equations:

$$x = (I - U)^{-1} y$$

where x = an n-component vector of output;

U = the variable input-output coefficients which

depend on the primary input prices, tax rates, input elasticities and technical progress parameters;

y = final demand component vector.

A one-dollar change in final demand creates a chain impact on industrial outputs. The chain impact is traced by the usual output, income, and employment multipliers. These multipliers are calculated as belows.

There are definitions:

$W = (I - U)^{-1}$: an n by n direct and indirect requirement matrix.

$(W_{ij}, i, j = 1, 2, \ldots n)$

h : an n component vector of income coefficients.

$(h_i, i = 1, 2, \ldots n)$

e : an n component vector of employment coefficients.

$(e_i, i - 1, 2, \ldots n)$

output multipliers : $TM_j = \sum_{i=1}^{n} \overline{W}_{ij}$ ......(3-9)

income multipliers : $IM_j = \sum_{i=1}^{n} \overline{W}_{ij} \cdot h_i$ .....(3-10)

employment multipliers : $EM_j = \sum_{i=1}^{n} \overline{W}_{ij} \cdot e_i$ ......(3-11)

$(j = 1, 2, \ldots n)$

So far, there are assumptions that the market condition is near perfect competition, and the price and output levels are determined by free market forces. The prices go up or down in response to the change in input costs or technical progress. When the costs of purchased materials, labor, or capital equipment increase, the industries will charge higher prices on their products. The higher prices of output discourges waste and the output sold in the market becomes smaller.

However, the assumption of perfect competition and no government intervention are far from reality in Korea. The Korean government controls prices of more than half of the products produced in Korea. To make the model more realistic, it is assumed that the government controls some industrial prices and these prices enter the model exogenously.

The prices charged by the first k industries are determined by free market forces and the remaining(n-k) prices are fixed by government intervention. The price frontier equations(2-15) become as below:

$$\ln p_j - \sum_{i=1}^{n} A_{ij} \ln p_i$$

$$= c_j - \ln(1-t_j) + B_j \ln v_j + C_j \ln w_j$$

$$+ D_j \ln r_j + \sum_{i=k+1}^{n} A_{ij} \ln p_i \qquad \ldots\ldots(3\text{-}12)$$

$$(j = 1, 2, \ldots n)$$

The price levels of the first k industries are jointly determined by the k price frontiers (3-12). The government regulated prices(p_i, i = k+1, k+2, ...,n) affects the equilibrium price levels. The variable input-output coefficients are determined by equation (2-18). All other derivation will work for this case. The only change in the (n-k) regulated prices enter the model exogenously for the regulated market model.

IV. EMPIRICAL FINDINGS

The 60 sector interindustry transaction table compiled by Bank of Korea for 1980 [Ref. 9] was used as the base data for this study. The 60 sector transaction was aggregated into a ten sector model. The aggregation was done by adding columns and rows of the transaction matrix. Table II provides the industrial classification of the ten sector model.

The ten-sector model includes four energy industries and six non-energy industries. The energy industries are coal mining, coal products, petroleum products, and electricity and gas. The non-energy industries include primary industries, manufacturing and construction, commercial service, other industries, government enterprise, and grains and meat processing. Primary industries include agriculture, fisheries, and mining except for coal mining and grain farming. Non-energy related manufacturing industries are included in manufacturing and construction sector. The other industries include the social and government services.

TABLE II

Industrial Classification

Ten Sector Model	Industrial Code by 60 Sector BOK Model
1. Primary industry	2-6, 8, 9.
2. Manufacturing and construction	11-15, 17-26, 28-30, 33, 34, 36-45.
3. Commercial service	49, 54, 56.
4. Other industry	55-60.
5. Coal mining	7.
6. Coal products	32.
7. Petroleum products	31.
8. Electricity and gas	47.
9. Government enterprise	16, 27, 35, 46, 48, 51-53.
10. Grains and meat processing	1, 10.

A. INPUT ELASTICITIES

From the 1980 input-output transation matrix, input elasticities, labor coefficients, capital coefficients, and effective tax rates were computed. Under the Cobb-Douglas production frontiers, the input elasticities become the input share after tax (the Cobb-Douglas production frontier will be used in this study because of difficulty of obtaining reliable elasticity of substitution by each industry in Korea), i.e.

$$A_{ij} = \frac{p_i x_{ij}}{(1-t_j) p_j x_j} \quad \ldots\ldots (4-1)$$

The labor coefficients and capital coefficients are obtained from equation (2-12) and (2-13).

$$C_j = \frac{w_j L_j}{(1-t_j) p_j x_j} \quad \ldots\ldots (4-2)$$

$$D_j = \frac{r_j K_j}{(1-t_j) p_j x_j} \quad \ldots\ldots (4-3)$$

The service of money is not identifiable from the 1980 input-output transaction table. It is included in the service of capital(K_j).

The input elasticity shows the output response to the input change. For example, the primary input elasticity with respect to the petroleum product is 0.7760. It implies that a one percent change in primary input will change 0.776 percent of the petroleum products. It is intuitively clear that the crude petroleum is the major input to the refinery products.

The largest input elasticity for the primary industry is the capital input which is 0.4937, followed by labor input, 0.1515; and manufacturing input, 0.1030. These three inputs contribute approximately 75 percent of the primary outputs.

TABLE III

Input Elasticities, Labor Coefficients,
Capital Coefficients, and Tax Rates

1. Input Elas	a	b	c	d	e	f	g	h	i	j
a. Primary	0.0876	0.0622	0.0003	0.0091	0.0896	0.0002	0.7760	0.0001	0.0340	0.1313
b. Mfg	0.1030	0.4690	0.0427	0.1680	0.0815	0.0144	0.0138	0.0190	0.0792	0.0632
c. Service	0.0213	0.0614	0.0286	0.0927	0.0243	0.0253	0.0064	0.0907	0.0433	0.0098
d. Other	0.0152	0.0230	0.0571	0.0641	0.0207	0.0164	0.0086	0.0058	0.0414	0.0024
e. Coal mng	0.0016	0.0011	0.0000	0.0005	0.0015	0.6200	0.0000	0.0241	0.0007	0.0000
f. Coal prd	0.0015	0.0007	0.0047	0.0021	0.0000	0.0058	0.0000	0.0000	0.0031	0.0000
g. Petro	0.0396	0.0300	0.0089	0.0125	0.0102	0.0167	0.0503	0.5046	0.1192	0.0021
h. Electric	0.0029	0.0182	0.0056	0.0067	0.0496	0.0124	0.0032	0.0057	0.0141	0.0006
i. Gov't cnt	0.0471	0.0567	0.0421	0.0361	0.0306	0.1405	0.0114	0.0503	0.1223	0.0465
j. Gra & mt	0.0348	0.0292	0.0000	0.0184	0.0000	0.0000	0.0000	0.0000	0.0000	0.0204
2. Coefficients										
a. Labor	0.1515	0.1112	0.1266	0.4488	0.5671	0.0584	0.0244	0.0901	0.2049	0.0436
b. Cpt-money	0.4937	0.1379	0.6832	0.1413	0.1248	0.0900	0.1054	0.2094	0.2310	0.6801
3. Tax Rates	0.0074	0.0322	0.0286	0.0112	-0.0632	0.0150	0.1382	0.0468	0.0564	0.0039

The energy inputs to the primary industry constitute less than five percent of the primary output.

As expected, 0.4690, to the manufacturing industry, followed by the capital input, 0.1379; labor input, 0.1112; primary input, 0.0622 and commercial service, 0.0614.

Major sources of energy to the manufacturing industry are electricity and refinery products. Its input elasticity is 0.0300, for refinery products and 0.0182 for the electricity and gas.

Labor is the single largest input into coal mining. The labor coefficient to coal mining is 56.71 percent followed by the capital input, 0.1248; primary, 0.0896; and manufacturing and construction, 0.0815. The electricity is the major source of energy to the coal mining industry. Its input elasticity is 0.0496, followed by the petroleum products, 0.0102.

Crude petroleum is the largest input to the petroleum product industry. Its input elasticity is around 0.7760, followed by the capital input, 0.1054. The labor input elasticity is very small, 0.0244, which reflects the highly automated refinery system. The electricity industry burns a lot of fuel oil to run the generators. The petroleum product input elasticity for the electricity generating industry is 0.5046, followed by the capital input, 0.2094; commercial service, 0.0907; labor input, 0.0901; and

government enterprise, 0.0503. The heavy use of refinery products for the electricity generation reflects the dominance of the thermal power plants over the hydro power plants in Korea. Approximately 90 percent of the elctricity is supplied by the themal power plants.

The effective tax rates vary from 0.1382 on refinery products to -0.0632 on the coal mining industry. The negative tax rates imply subsidy by the government.

B. MULTIPLIER ANALYSIS

The primary inputs were divided into labor, capital, and money. The 1980 input-output transaction table provides a combined figure of the payments for capital and money services. Instead of separating these two, they are combined, and will be called the capital-money input.

An increase in the wage rate is considered to be inflationary because the firm passes the cost increase on the final users by raising the price of output assuming the profit margin is not adjusted. All other industries which use the product as input are forced to increase thier prices since the input cost has risen. The wage-related price multipliers answer the question.

The price increase due to the wage hike is relatively mild in most industries. The least inflationary impact due to a one percent wage hike comes to the grain and meat

TABLE IV

Multiplier Analysis

Industry	price			
	non-tax	wage	capital-money	output
Primary	-0.03899	0.005891	0.019200	0.01759
Manufacturing	-0.04659	0.005080	0.006299	0.02768
Commecial svc	-0.01865	0.002361	0.012740	0.01396
Other industries	-0.01544	0.006929	0.002181	0.01882
Coal mining	-0.01702	0.009654	0.002125	0.01717
Coal products	-0.01034	0.000604	0.000929	0.02546
Petro products	-0.02380	0.0005813	0.002509	0.02363
Electricity	-0.01259	0.001134	0.002636	0.02476
Gov't enterprise	-0.02194	0.004495	0.005068	0.02231
Grain & Meat	-0.01324	0.000577	0.009005	0.01564

industry(0.000577), followed by petroleum refining (0.0005813), coal product industry(0.000604), electricity (0.001134), and commercial service industry(0.002361). The insensitivity of the wage hike on inflation is because the cost of labor share is minimal in these industries. The labor share of grain and meat industry is only 4.36 percent and that of petroleum refining is 2.44 percent. Industries such as coal mining, other industries, government

enterprise, and primary industrues, which have relatively high labor costs compared with other costs have relatively significant inflationary impacts when a wage hike is introduced. The largest inflationary impact comes to the coal mining industry. A one percent increase in wages in the coal mining industry results in a 0.9654 percent increase in price levels. The inflationary impact of a one percent wage hike is 0.005891 for primary, 0.005080 for manufacturing, 0.002361 for commercial service, 0.004495 for government enterprise, and 0.006929 for other industries.

The capital-money input includes the services of both money and capital. Any payment for the service is part of costs. Payment of interest, cost of capital and land prices are examples of such costs. An increase in these costs is passed on the user of the products. The primary industry, which spends around fifty percent of its value of production on the capital-money service, has the largest capital-money-related price multipliers. This implies that a one percent increase in the price of capital and money will increase the inflation rates for the Korean economy by 1.92 percent. Commercial service, which depends more than 68.32 percent on capital and money service, has the second largest capital-money-related multipliers(0.01274), followed by grain and meat(0.009005), manufacturing (0.006299), and government enterprise(0.005068). The industries such as

coal mining, coal products, petroleum products, electricity, and other industries, have relatively small capital-money-related multipliers, a value between 0.000429 and 0.002636.

The amount of tax on industry is part of the expenses which firms pass on thier output prices. If more taxes are imposed on industries, the rate of inflation will rise. The model computes the non-tax portion tax related price multiplier instead of the tax related price multiplier. The non-tax related price multiplier shows how much a tax cut contributes th the fight against inflation. The largest non-tax portion related price multiplier comes to the manufacturing industry(-0.04569), followed by primary industry(-0.03889), petroleum products(-0.02380), and government enterprise(-0.02194). Coal products has the least non-tax related price multiplier(-0.01034). Electricity and grain & meat are relatively smaller non-tax related price multipliers. The study shows that a tax hike is more inflationary than either a wage hike or a capital-money price hike. Although there is industrial variation, the tax cut, particularly in manufacturing and primary industries, is the most effective way to fight inflation while keeping the rate of growth of the money stock constant. Any deficit financing by printing more money and simultaneous tax cut won't work because the

capital money-related price multipliers are strong in primary, manufacturing, and commercial service industries. The model tentatively suggests that a tax cut alone could be the best way to fight inflation. A wage hike contributes mildly to inflation. It is clearly not the key factor in Korean inflation. Taxes and the capital-money prices are the key sources of inflation in the Korean economy in addition to the prices of imported goods.

The capital-money related price multipliers are relatively small for the industries which are subsidized by the government, either by lower interest rate loans, or by direct subsidy as in the case of coal mining, petroleum refinery, electricity, government enterprise, and other social commercial industries. The rate of growth of the money supply and interest rates on loans are the key factors to increase the service price of capital-money input.

One dollar spent on a final demand creates more than one dollar output for the economy. Such a chain impact is measured by the output multipliers. In general, the industry which has the smaller value added coefficients provides the larger output multipliers. The manufacturing industry provides the largest output multiplier(0.02768), followed by coal products(0.02546), electricity(0.02476), petroleum(0.02363), government enterprise(0.02231), and primary industry(0.01759). Commercial service industry

which has the largest value added coefficients(0.00909) has the smallest output multiplier.

C. SIMULATION ANALYSIS

The 1979 OPEC price hike and the world wide inflation, particularly in the U.S., are considered to be the main source of the Korean inflation. At least, these import related cost-increases play a pivotal role in Korean inflation. To pay high energy and import costs, industry needs more money. A shortage of money will lead the economy to recession and more unemployment. To avoid the apparent recession, government increases the supply of money which fuels the rampaging inflation further. Labor demand higher wages to catch up the cost of living. Government has no choice but to increase the ceiling on the essential commodity prices to allow the industries to recover the cost increases. The vicious circle of inflation struct the Korean economy hard in 1979 when the OPEC countries raised thier crude petroleum prices three times within less than seven months.

By using the variable input-output model, the inflation and recession on the Korean economy which results from the OPEC price hike will be simulated.

Consider the following three cases of price hike.

(1). Only the petroleum price is hiked with all other energy prices and government control prices

remaining unchanged;

(2). Prices of all energies are hiked while other government control prices remain unchanged. The energies include coal mining, coal products, petroleum products, and electricity and gas;

(3). Prices of all energies and other government controlled items are increased.

The inflationary impacts on primary, manufacturing and construction, commercial services, and other industries will be evaluated for each of the three cases.

A ten percent increase in price of petroleum products boosts the price of primary products by 0.52 percent, the price of manufacturing and construction by 0.65 percent, the service price by 0.14 percent, and other price by 0.27 percent. The net impact on the petroleum price hike is very mild. A forty percent increase in the petroleum price only results in 2.06 percent price increase in primary price, and 2.59 percent increase in manufacturing price. Commercial service price is up 0.54 percent by the forty percent petroleum price hike.

Thr OPEC price hike itself is not that inflationary. The concern on OPEC price hike is because of its "snow-ball" effect. The inflationary forces accumulate as they proceed to succeeding rounds. It is assumed that all energy prices in Korea are controlled by government.

TABLE V

Simulation Results on Inflation

(unit: percent)

	Primary	Manuf'g & construc	Commercial service	Other industry
(1). Price of petroleum products is hiked by				
10%	0.52	0.65	0.14	0.27
20%	1.03	1.29	0.27	0.54
30%	1.45	1.94	0.41	0.81
40%	2.06	2.59	0.54	1.07
(2). Prices of all energies are hiked by				
10%	0.63	1.06	0.27	0.46
20%	1.26	2.12	0.55	0.91
30%	1.90	3.18	0.82	1.37
40%	2.53	4.24	1.09	1.83
(3). Prices of energy and gov't controlled items are hiked by				
10%	1.78	2.96	0.85	1.45
20%	3.54	5.84	1.69	2.88
30%	5.46	9.15	2.57	4.41
40%	7.08	11.68	3.38	5.76

There is a simulation of the variable input-output model by raising prices of all energies which include coal mining, coal products, electricity and gas, and petroleum product.

A ten percent increase in all energy prices forces the primary price up by 0.63 percent; the manufacturing price up by 1.06 percent; the commercial service price up by 0.27 percent, and other prices up by 0.46 percent.

A forty percent increase in all energy prices only results in a mild inflation. Primary price and service prices increase only 2.53 percent and 1.09 percent respectively. Manufacturing price increased by 4.24 percent due to the forty percent energy price hike. It did not rise to twenty percent inflation which the Korean economy has experienced for several years.

To investigate the "snow-ball" effect of inflation, all energy prices and other government controlled prices are raised.

A ten percent increase in all government controlled prices including energy prices result in somewhat strong inflationary impact. The manufacturing price goes up as much as 2.96 percent, followed by the primary price, 1.78 percent and other price, 1.45 percent. The commercial service price was still a minimal increase, 0.85 percent. A forty percent price hike could boost the manufacturing prices as much as 11.68 percent and the primary price by

7.08 percent. The commercial service and other prices are only up by 3.38 percent and 5.76 percent respectively.

There is an assumption that there are no changes in final demand components in these simulations. It is not surprising that Korean inflation runs around twenty percent if all other inflationary sources such as taxes, interest on loans, wage hike, particularly that of skilled labor and other importing costs are added.

What are the best ways to stop inflation? Monetarists blame the rapid increase in money stock as the cause of the surging inflation. Fiscalists blame the uncontrollable outside shock such as the OPEC price hike and the inflation on imported goods. An increase in the money supply is frequent action to avoid depression and mass unemployment.

The model sees the "snow-ball" effect as the source of the Korean inflation. The OPEC price hike, import price hike, or wage hike alone creates a mild inflationary pressure. Rampaging inflation comes as these costs pass on other prices.

A lack of competition among suppliers suggest that the firms could charge virtually any prices for their products. These outside shocks provide justification for price increases. The price increase is usually done by a negotiation between government and the industries. It appears that government accepts the inflated industry cost

data which worsens the "snow-ball" effect. Another aspect of Korean inflation is an unpredictable increase in money stock which makes the price of money expensive. The high cost of holding money makes speculative investment more attractive, which in turn accelerates the price of money and inflation.

The present model provides a tool by which government can minimize the "snow-ball" effect on Korean inflation.

Next, the growth impact of the supply shock will be discussed. The variable in input-output model [Ref. 10] is simulated to see how much recession is expected to come when each of the three cases is implemented into the model. The distinguishing feature of the present model is its capability to allow the optimizing behavior of firms. Firms substitute less expensive inputs for expensive ones. Given final demand, the industry which produces expensive products slows down its growth because of the shrunken demand by other industries. Facing the input cost increase, firms optimize their industrial mix so as to minimize their cost. In this process, the industrial structure and the technical coefficients change. The conventional input-output fails to incorporate such optimizing behavior of firms.

Consider the following three cases:

(1). Only petroleum prices are hiked.

(2). All energy prices are hiked.

(3). All government cotrolled prices are hiked.

Table VI

Simulation Results on Industrial Purchasers

(Unit: percent)

	Pri-mary	Mfg	Ser-vice	Other	Coal mining	Coal product	Petro	Elec	Gov't cnt	Grains & meat
1. Price of petroleum product is hiked by										
10%	-0.492	-0.741	-0.069	-0.242	0.184	0.094	-17.50	0.332	0.157	0.101
20%	-0.962	-1.475	-0.052	-0.482	0.371	0.189	-31.91	0.666	0.316	0.203
30%	-1.408	-2.203	-0.077	-0.720	0.561	0.285	-43.78	1.005	0.477	0.307
2. Prices of all energies are hiked by										
10%	-0.195	-1.178	-0.048	-0.382	-14.19	-11.99	-16.85	-15.33	0.348	0.177
20%	-0.344	-2.236	-0.090	-0.759	-26.21	-22.39	-30.79	-28.17	0.709	0.359
30%	-0.443	-3.476	-0.122	-1.129	-36.40	-31.45	-42.35	-38.96	1.085	0.545
3. Prices of energies and gov't controlled items are hiked by										
10%	2.30	-2.215	0.378	-0.664	-11.86	-11.08	-13.12	-13.21	-11.35	-10.56
20%	4.79	-4.327	0.823	-1.272	-22.21	-20.85	-24.42	-24.58	-21.33	-19.96
30%	7.49	-6.337	1.342	-1.882	-31.26	-29.47	-34.15	-34.36	-30.11	-28.31

When the price of petroleum product is hiked by a ten percent, the demand for petroleum products drops and that for other energies goes up. The petroleum demand is down by as much as 17.5 percent. Electricity and gas demand goes up by 0.332 percent. The petroleum price hike forces industry and consumer to buy more coal and coal products. Their demands are up by 0.184 percent and 0.094 percent. As expected, overall industries slow down their growth rates. Manufacturing industry reduces its output by 0.741 percent. The growth rate of primary industry and that of the commercial service industry are down by 0.492 percent and 0.069 percent respectively.

A drastic increase in petroleum price, let say a thirty percent increase, forces firms to switch to other sources of energy. In this case, the electricity demand is up by as much as 1.005 percent, followed by coal mining, 0.561 percent, and coal products, 0.285 percent. These energy demands are the net effect of more demand by substitution and less demand by recessions. The thirty percent price hike hurts the manufacturing and construction industry most. Its growth rate is down by 2.203 percent. The primary industry and commercial service slow down their growth by 1.408 percent and 0.077 percent respectively.

The initial effect of any drastic increase in the petroleum price is rather mild both on inflation and

recession. To investigate the "snow-ball" effect on recession, the model by increasing prices of all energies is simulated. There are clear signs of substitution from energies to non-energy inputs.

A ten percent increase in price of all energies reduces demand for coal mining by 14.19 percent, demand for coal products by 11.99 percent, demand for petroleum products by 16.85 percent, and demand for electricity by 15.33 percent. Industries purchase more products and service provided by non-energy government enterprise. Its growth has increased by 0.348 percent after the ten percent price hike. The grain and meat industry is also stimulated by the energy substitution. Its demand grows by 0.307 percent.

The growth rates of primary, manufacturing, and service industries slow down. The primary industry is down by 0.195 percent, manufacturing down by 1.178 percent, and commercial service down by 0.048 percent. A thirty percent price hike of all energy prices reduce the growth rate of primary by 0.443 percent, that of manufacturing by 3.476 percent, and that of commercial service by 0.122 percent. The primary industry is more stimulated when prices of all energies are hiked than when only price of petroleum product is hiked. A thirty percent price hike in petroleum product alone hampers the growth of primary industry by 1.408 percent whereas a thirty percent of price hike in all energies reduces the growth of primary industry only by 0.443 percent.

An increase in the growth rate on primary industry from -1.408 to -0.443 indicates a clear sign of substitution between energy and primary input. As an illustration of such substitution, it may be considered the case where industries buy more animal-fish oil, vegetable fuel such as alcohol, or methane from animal waste, instead of buying conventional energies which are now too expensive. Also there is more demand for the products and services by non-energy government enterprises. What would happen to Korean economy if all energy prices and government controlled prices go up? When energy controlled prices go up, the industries and households consume more primary products and commercial services. The model predicts that a ten percent increase in price of all energies and government controlled items could stimulate the primary industry by 2.30 percent, and the commercial service industry by 0.378 percent. However, the manufacturing industry would slow down as much as -2.215. A thirty percent increase in all government controlled items including energies could stimulate the primary industry as much as 7.49 percent and the commercial service industry by 1.342 percent. The manufacturing industry would be down by 6.337 percent. All energy demands are down somewhere between 29.47 percent to 34.36 percent when all controlled prices are hiked by thirty percent.

V. CONCLUSION

Growth, inflation, and energy are the crucial issues which the Korean economy faces today. A variable input-output model was employed as a tool for such an investigation. The model responds to the industry's efforts to substitute less expensive inputs for expensive ones. Industries are very sensitive to the cost change.

The supply shock such as the OPEC price hike, wage hike, or import price hike has a rather mild initial impact on inflation and growth. The aggravating thing is the "snow-ball" effect. To minimize the "snow-ball" effect, government should promote the competition among suppliers and minimize the cost of holding money so that the price of money is cheaper. Tax and price of money have rather large price multipliers.

Efficiency through competition and reduction of price of money through stable expectation are the long-run solution for stagflation. The stable expectation may be formulated by the steady growth of money and competition will be promoted by reducing unessential government controls, regulations, and subsidy. However, the short-run solution for the stagflation is to minimize the "snow-ball" effect.

The present model provides an insight to the short-run solution.

LIST OF REFERENCES

1. Song heeyhon, "An Econmetric Forecasting Model of the Korean economy", *Planning Models and Macroeconomic Policy Issues*, Edited by Chuk Kyo. Kim, Seoul, Korea: KDI, 1977.

2. Park, John-goo, "Macroeconomic Model Building in Korea", Central *Bank Macroeconomic Modeling in Pacific Basin Countries*, Federal Reserve Bank of San Francisco, 1976.

3. Bank of Korea, *Input-Output Table and Supporting Materials* for *1963*, *1965*, *1967*, *1975* and *1979*. Seoul, Korea: Research Department.

4. Walras, L. *Elements of Pure Economics*, (English Edition). George Allen and Urwin, London, 1954.

5. Hudson, E. A. and Jorgenson, D W., "U.S. Energy Policy and Economic Growth, 1975-2000", *The Bell Journal of Economics* and *Management Science*, Vol. 5, No. 2(1974).

6. Arrow, K. J., and Hoffenberg, M. *A Time Series Analysis* of *Interindustry Demands*. Amsterdam: North-Holand Publishing Company, 1959

7. Bacharach, M. *Biproportional Matrices and Input-Output Change*. Cambridge: Cambridge University Press, 1970

8. Liew, C. K., "Dynamic Multipliers for a Regional Input-Output Model", *The Annuals of Regional Science*, Vol. XI, No. 3 (November 1977)

9. Bank of Korea, *1980 Input-Output Tables(II)*, Seoul, Korea., 1982.

10. Liew, C. K., and C. J. Liew, "Energy Simulation with a Variable Input-Output Model", *1979 Proceedings of the Business and Economic Statistic Section of the American Statistical Associations Meetings*, 1979.

INITIAL DISRIBUTION LIST

No of Copies

1. Defense Technical Information Center 2
Cameron Station
Alexandria, Virginia 22314

2. Library, Code 0142 2
Naval Postgraduate School
Monterey, California 93943

3. Department Chairman, Code 54 1
Dept. of Administrative Sciences
Naval Postgraduate School
Monterey, California 93943

4. Professor J. W. Creighton, Code 54 Cf 2
Dept. of Administrative Sciences
Naval Postgraduate School
Monterey, California 93943

5. Professor Carl R. Jones, Code 54 Js 2
Dept. of Administrative Sciences
Naval Postgraduate School
Monterey, California 93943

6. Sang Chul Chang 5
32-4 Seosung-Dong
Sangju-Eub, Sangju-Gun
Kyong buk, Korea 642-00

7. Yong Roo Hwang 5
570-1, Dalseo Apt 6-506
Sungdang-Dong, Seo-Gu,
Taegu, Korea 630-10

8. Personnel Management Office 2
Army Headquarters
Seoul, Korea 140-01

9. Office of the Defense Attache 1
Embassay of the Republic of Korea
2320 Massachusetts Avenue, Northwest
Washington, D.C. 20008

10. Library Officer 2
Korean Military Academy
Seoul, Korea 130-09

[illegible]

205666

Thesis
C3716 Chang
c.1 A variable input-output model for inflation, growth, and energy for the Korean economy.

22 FEB 87 32410

205666

Thesis
C3716 Chang
c.1 A variable input-output model for inflation, growth, and energy for the Korean economy.

AMERICAN BINDERY
TOPEKA, KANSAS

thesC3716
A variable input-output model for inflat
3 2768 002 09711 5
DUDLEY KNOX LIBRARY